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(54) Manufacturing method of optical fiber preform

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21 PRTS

DETAILED DESCRIPTION

Subject of Invention

Manufacturing method of optical fiber preform

Scope of the Patent Claim

1. A manufacturing method of optical fiber preform having the following characteristics: By utilizing the ultrasonic wave vibration, the glass composition liquid raw materials are made into mists; these mist particles are mixed with gases containing oxygen & hydrogen and combusted to generate a flame, containing glass soots, which is collided onto a target to deposit a glass block.

Detailed Explanation of th4e Invention

Previously, the present inventors have proposed a method in that the glass composition liquid raw materials are made into mist state by a gas containing hydrogen, then the mists are mixed with oxidizing gas and combusted; the flame is blown onto a target to deposit a glass block for optical fiber. In this method, characteristically, the glass block can be deposited in high speed and high yield and furthermore, it can be manufactured continuously. However, there is a problematic point that if the glass block is deposited at ultrahigh speed of more than 100 g/hr, the gas pressure would become too high; thus the mist particle forming speed would become too fast to cause lowering in the deposition yield.

In order to solve the aforementioned problematic point, in the present invention a method in that the glass composition liquid raw material is made into mist by utilizing a electromechanical transducer such as the ultrasonic wave

vibration. Namely, in this method to a ultrasonic wave vibrator, a vibration-enlarging horn is attached, and to the glass composition liquid raw material supply hole opened to the front end surface of this vibration-enlarging horn, a device for delivering the aforementioned liquid is provided so that the aforementioned liquid which reaches the front end surface of the vibration-enlarging horn would be converted to mist by the ultrasonic vibration; the mist particles are mixed with a gas containing oxygen and hydrogen and combusted to generate a flame containing the glass soots. And this flame is collided onto a target to deposit a glass block.

Below, the method of the present invention is illustrated by referring to figures.

Fig 1 is an outline diagram illustrating the glass block manufacturing method of the present invention. 1 is the ultrasonic wave vibrator; to the top-end of this, the vibration-enlarging horn 2 is fixed. The ultrasonic vibrator 1 and the vibration-enlarging horn 2 are both arranged to the position where the vibration of the vibration-enlarging horn 2 would become zero; namely arranged into the inside gas supply pipe 7 through the plural number of supports 15 fixed to the front ("front" is best guess; 1 character illegible) portion 14. In this inside gas supply pipe 7, it is set up that from the arrow 10 direction, H_2 or a H_2 gas containing at least more than one kind selected from N_2, He, Ar, Ne, etc. is delivered and sprayed from the nozzle 7'. And the inside gas supply pipe 7 is covered by the inert gas supply pipe 8 and the oxidizing gas supply pipe 9. These supply pipes are constructed in concentric shape 3-layer structure. In the inert

gas supply pipe 8, from the arrow 11 direction, the inert gas of N_2, He, Ar, Ne, etc. is delivered and the gas is set to be spayed from the nozzle 8'. In the oxidizing gas supply pipe 9, from the arrow 12 direction, the oxidizing gas of O2, CO2, NO2, air, ozone, etc. or the aforementioned oxidizing gas containing the vapors of the glass raw material of $SiCl_4$, BBr_3, etc. is delivered is delivered and the gas is set to be spayed from the nozzle 9'. The nozzle 7', 8' and 9' are constructed in concentric 3-layer tube structure. 4 is the lead wire connecting the ultrasonic wave oscillator 3 and the ultrasonic vibrator 1. 5 is the glass composition liquid raw material supplying equipment and connected to the glass composition liquid raw material supply hole 13 which is opened to the front-end surface of the vibration-enlarging horn 2 through the supply pipe 6. The liquid raw material reaches the front-end surface 13 of the vibration-enlarging horn 2 via the supply pipe 6 from the glass composition liquid raw material supply equipment 5 would form thin liquid film by the surface tension; however, by receiving the effect of the applied vibration of the ultrasonic wave vibration, it would become fine particles and scatter forward. In this case, the property of the fine particles created by this function is that since the liquid raw material is made into mists by utilizing the vibration of the vibration energy converted from an electrical energy by an ultrasonic wave vibrator, the particle speed and the motion energy would be extremely small. Therefore, the fine particles scattered forward would be transported by the H_2 gas supplied from the arrow direction 10 and sprayed from the nozzle 7' And, at the nozzle exit portion, the H_2 gas would be lit and combusted; simultaneously, from the arrow 11 direction and the arrow 12

direction, the inert gas and the oxidizing gas are flowed, respectively. By this, the flame 16 containing glass soot is generated to the front of the 3-layer tube nozzle. This flame is blown onto the target which is being rotated to the arrow 20 direction and moved to the arrow 19 direction. By this, the glass soots or the glassified (consolidated to glass) rod 17 would be deposited onto the target.

Fig 2 is an outline diagram illustrating the glass block manufacturing method characteristically in that the method of converting the liquid raw material to mist by utilizing an ultrasonic wave vibration is employed in conjunction with the method proposed previously by the present inventors in that the liquid raw material is converted to mist by a gas containing hydrogen. The characteristic of this method is that the amount of the liquid mist can be controlled by the electrical energy amount to be applied to the ultrasonic wave vibrator and also by the flow rate of the gas containing hydrogen; thus the degree of freedom in the control is increased. Namely, by delivering the gas containing hydrogen from the supply equipment 21 to the gas supply hole 13' opened to the front-end surface of the vibration-enlarging horn 2 through the gas supply pipe 22, the liquid raw material from the glass composition liquid raw material supply equipment 5 is forcefully sucked up to the glass composition liquid raw material supply hole 13" through the glass composition supply pipe 6 to be converted to mist, and simultaneously, the liquid would also be made into mist by the applied vibration of the ultrasonic wave vibration. As a result, the amount of the mist of the liquid can be increased compared to the situation shown in Fig 1. Furthermore, from the arrow 10' direction and from the arrow direction 11', the inert gas and the oxidizing gas are

flowed, respectively. The glass composition raw materials which can be applied to the present invention include alkyl compounds, halogen compounds, silicone compounds composed of hydride, the aforementioned silicone compounds containing refractive index controlling compound, silicone compounds dissolved or dispersed into alcohol and/or water, etc. For the ultrasonic wave vibrator to be used in the present invention, as shown in the implementation example, the magnetic distortion type vibrator or the electric distortion type vibrator can be employed. The frequency of the vibrator and the input electrical power can be determined by the amount of the mist to be converted from the liquid. The frequency of the vibrator is generally set to be in the range of several KHz to 100 KHz. The input electrical power to be used is in the range from ten-odd W (10 + several W) to several hundreds W. And the amount of the liquid mist would differ depending on the surface tension value of the liquid, the material of the horn contacting the circumference edge of the liquid film of the vibration-enlarging horn, the affinity of the liquid and the material (of the horn), the structure of the horn, etc. For the structure of the enlarging-horn, the exponential type (shape), conical type (shape), simple step attached horn, or a composite type of combining the above can be used.

Fig 3 is an example showing the relationship between the electrical power inputted to the ultrasonic wave vibrator and the amount of the liquid converted to mist in the case that in the equipment shown in Fig 2, tetraethoxy silane [$Si(OC_2H_5)_4$] was used for the liquid and the ultrasonic-enlarging horn was formed by aluminum. The results obtained are based that the exponential type horn was

employed and the vibration was performed by 20 KHz frequency. However, the flow rate of the H_2 gas delivered from 21 was 2 liter/min; the flow rate of the Ar gas delivered from the arrow direction 10' was 2.5 liter/min; the flow rate of the O_2 gas delivered from the arrow 11' direction was 5 liter/min, It is clear from the figure that by increasing the input electrical power, the amount of the mist converted from the liquid can be increased. Fig 4 shows the result in that the glass soots have been deposited onto a target of cylindrical shape (outside diameter 70 mm ϕ) possessing a half spherical shape at the bottom. This corresponds to the result shown in Fig 3. It shows glass soot deposition rate of 100 g/hr with input electrical power at 10-odd W (10 + several W), and 400 g/hr level ultrahigh speed glass soot deposition rate can be obtained with input electrical power at 20-odd W (20 + several W). In the conventional method, if this ultrahigh speed deposition rate is tried, the deposition yield would become below 10%. In contrast, by the method of the present invention, about 20% deposition yield has been realized.

As described above, according to the method of the present invention, the mist conversion quantity of the liquid can be controlled by the electrical energy and controlled amount can be varied in an extremely wide range; furthermore, it is not necessary to increase the gas pressure as required in the conventional method for increasing the amount to be converted to mist. Therefore, the speed of the converted mist particles would not be accelerated; thus the deposition yield onto the target can be enhanced.

Brief Explanation of Figures

Fig 1 and Fig 2 outline the cross sections of the optical fiber preform manufacturing equipment to be used in the implementation examples of the present invention. Fig 3 is a graph showing the relationship between the electrical power inputted to the ultrasonic wave vibrator and the amount of the liquid converted to mist. Fig 4 is a graph showing the relationship between the electrical power inputted to the ultrasonic wave vibrator and the deposition rate of the glass soot.

In the figures, 1 is an ultrasonic wave vibrator; 2 is a vibration-enlarging horn; 5 is a glass composition liquid raw material; 10 is the introduction direction of the gas containing H_2; 11 is the introduction direction of inert gas; 12 is the introduction direction of the oxidizing gas; 13 is the glass composition liquid raw material supply hole; 17 is a glass rod; 18 is a target; 21 is the supplying equipment of the gas containing H_2.

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09/762307

Fig 1

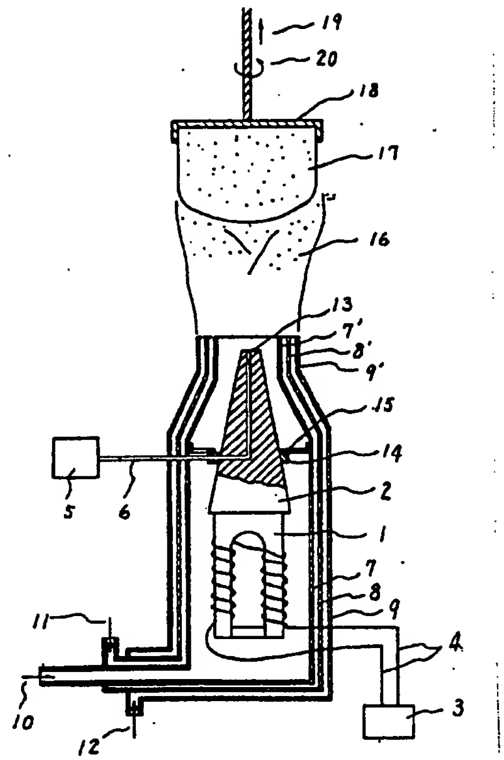


Fig 2

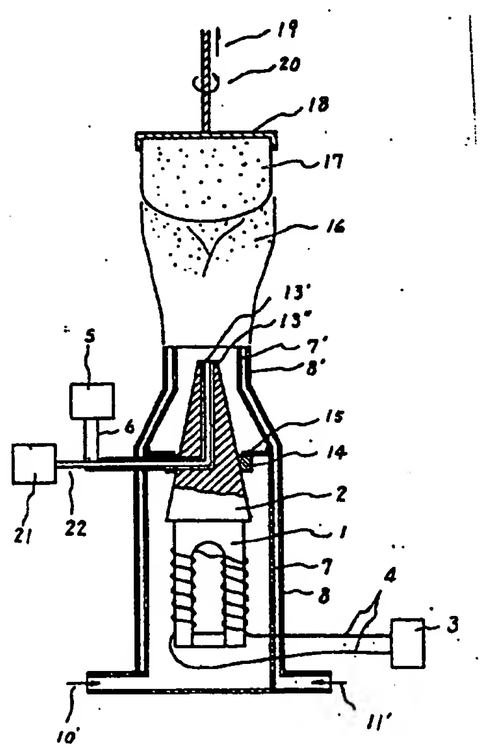


Fig 3

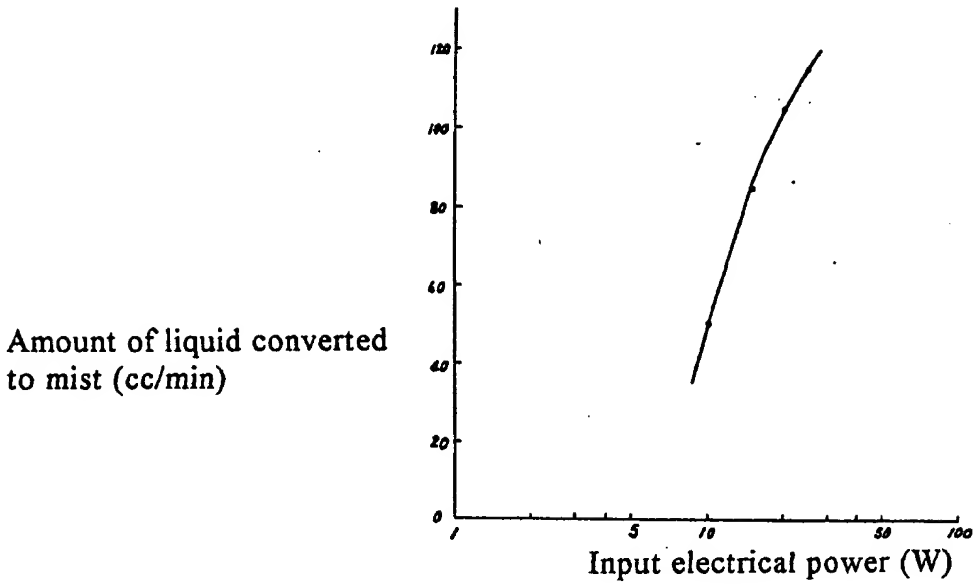
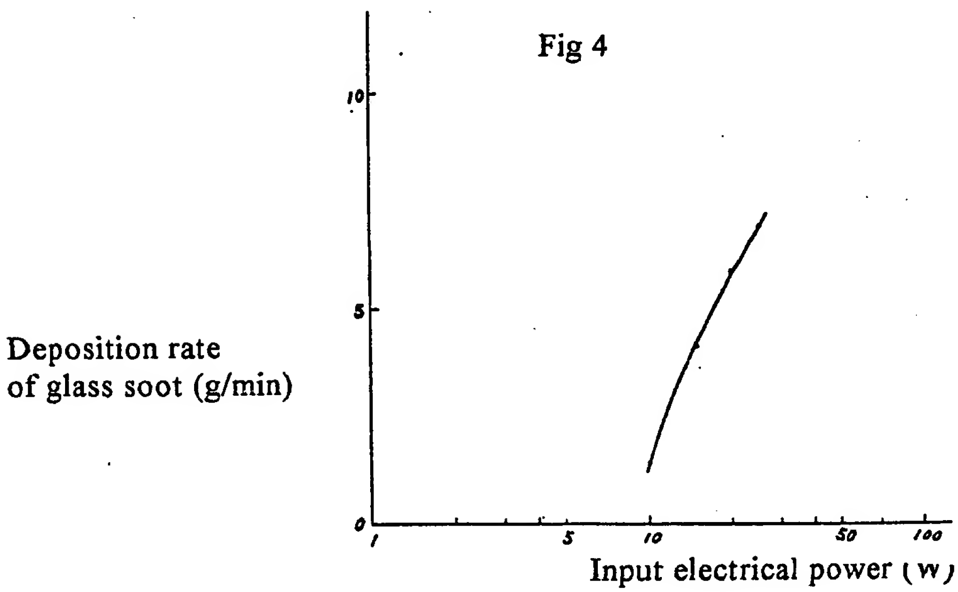

Amount of liquid converted to mist (cc/min)
120
100
80
60
40
20
0
1
5
10
50
100
Input electrical power (W)

Fig 4


Deposition rate of glass soot (g/min)
10
5
0
1
5
10
50
100
Input electrical power (W)